G|C ®

MODEL S9 and SD9

SQUARE WAVE STIMULATORS

INSTRUCTION MANUAL

®GRASS MEDICAL INSTRUMENTS SINCE 1935

QUINCY, MASS., U.S.A.

SERIAL # 021x3

MODEL S9 and SD9

SQUARE WAVE STIMULATORS

PLEASE DO NOT LOSE THIS MANUAL

ONE MANUAL IS SHIPPED with each instrument.

No "shortages" recognized.

Additional copies may be purchased at cost by owners of the instrument, but it is necessary to give the exact model and serial numbers.

The cost is $ 4.50

GRASS MEDICAL INSTRUMENTS SINCE 1935

QUINCY, MASS., U.S.A.

WARRANTY

Grass Instrument Company unconditionally warrants this instrument to be free from defects in materials and workmanship:

1. if the GIC seal (when present) is not broken,
2. if there is no evidence of abuse or attempted repairs without Grass Instrument Company authorization.

This warranty is binding for two years from date of initial delivery and is limited to: servicing and/or replacing any instrument or part thereof (except tubes, transistors or batteries) returned to the factory for that purpose with transportation charges prepaid and which to the company's satisfaction are found to be defective.

Until superseded or in contractual form, this warranty is made expressly in lieu of all other liabilities and obligations on the part of Grass Instrument Company.

DAMAGE UPON ARRIVAL

Each instrument leaves our plant after rigorous tests, in perfect operating condition. The instrument may receive rough handling and damage in transit. The shipment is insured against such damage. The buyer must report in writing immediately any concealed or apparent damage to the last carrier. Report any damage also to us, and issue an order for replacement or repair. Our invoice for such service will then be evidence in the claim.

DEFECTS OCCURRING WITHIN WARRANTY PERIOD

Because of the human element involved, parts of units may develop defects which no amount of initial testing will reveal. The price of our instruments makes provision for such service, but it does not:

1. provide for any transportation charges,
2. provide for services not performed or authorized by us,
3. provide for the cost of repairing instruments which have obviously been abused or subjected to unusual environments for which they have not been designed.

We will be happy at any time to discuss by phone or letter suspected defects or aspects of instrument operation which may be unclear. We advise you to inform us by phone or letter of the nature of the defect before returning an instrument for repair. Many times a simple suggestion will solve the problem without returning an instrument to the factory.

WARRANTY ON SPECIFICATIONS

Grass Instrument Company warrants each instrument to satisfy printed specifications available to the purchaser on formal request thirty days prior to date of scheduled delivery. Specifications are the average of typical measurements made on production units under controlled conditions. Statistical variations in individual units due to normal component variations are to be expected and should not alter the intended use of the instrument. However, when parameter characteristics are critical, tolerances are specified and guaranteed. Operating characteristics can be expected to change slightly from printed specifications with age and long term use.

Unless the exact tolerances of any parameter of any instrument are specified on the purchase order and specifically agreed to by Grass Instrument Company, it is assumed that our standard production tolerances will satisfy all contractual responsibilities.

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NEW

SQUARE WAVE STIMULATOR

WITH DELAY CIRCUIT AND STIMULUS ISOLATION

by GRASS

FOR STUDENT, OPERATING ROOM, AND LIMITED RESEARCH APPLICATIONS

- ▲ SOLID-STATE SD9 replaces SD5 and provides all parameter compatibility with Grass Stimulators. Delivers DC, single pulses, repetitive pulses and twin pulse pairs.
- ▲ POWER OUTPUT increased 50% over its predecessor the SD5. 25% increase in volts out.
- ▲ TWIN PULSE PAIRS for refractory measurements with variable time interval (DELAY) 0.02 to 200 MS.
- ▲ ± 5% ACCURACY on all parameters and all ranges (± 10% on VOLTS).
- ▲ REGULATED POWER SUPPLY ensures all parameter constancy even with fluctuations in line voltage.
- ▲ SYNCHRONOUS interfacing for CRO sweep, to drive another stimulator, or to be driven by other source.

Continuously variable PARAMETERS:

- ▲ FREQUENCY: 3 decades (0.2 to 200 P/S)
- ▲ DELAY: 4 decades (0.02 to 200 MS)
- ▲ DURATION: 4 decades (0.02 to 200 MS)
- ▲ DC OUTPUT VOLTS: Isolated 3 decades (0.1 to 100 V)
- ▲ OUTPUT IMPEDANCE: ≤ 1 K ohm
- ▲ MAXIMUM POWER OUT: 2.5 watts continuous
- ▲ SYNC IN: +15 to 50 V
- ▲ SYNC OUT: +30 V

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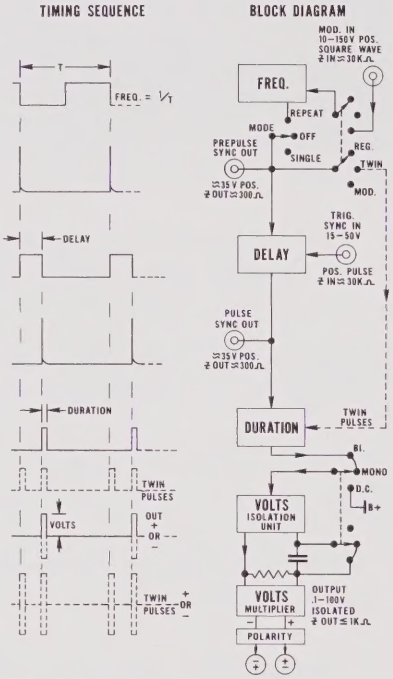
GRASS MODEL SD9 STIMULATOR WITH STIMULUS ISOLATION

The solid-state SD9, which replaces the SD5, provides increased power out, greater all parameter stabilization and additional lower range DELAY decade. The SD9 is intended for advanced student applications, teaching demonstrations and limited research applications where stimulus isolation is required, but not remote isolation. The SD9 which delivers DC, single pulses or repetitive pulses, has four continuously variable parameters. Stimulators can be coupled together to obtain trains of pulses. The SD 9 has all parameter compatibility with Grass Stimulators. The SD 9 differs from the S9 in that it has a variable delay function between the synchronous output pulses and the stimulus pulses. If greater range of parameters, greater output power, remote isolation, etc., are required, then the more sophisticated Grass research models are recommended.

FEATURES: The SD9 can be driven remotely by a single pulse or series of pulses. Frequency is thus controlled by the frequency or remote pulses whereas delay, duration, and voltage are determined by the SD9 controls. The SD9 can be used to drive another instrument. The TWIN PULSES switch enables selection of TWIN PULSES (same polarity) separated by a variable delay for some suitable refractory studies. Trains can be arranged to produce tetanizing stimulation. In this case, the first stimulator controls the group repetitive rate and duration. The second stimulator controls the rate, duration and voltage of pulses.

PULSE WAVEFORMS (not to scale)



DELAY FUNCTION is variable from 0.02 to 200 milliseconds and separates PREPULSE SYNC OUT pulse from the stimulus pulse. Also used to set refractory time interval for TWIN PULSE PAIR operation.

SYNCHRONOUS OUTPUT PULSES are 30 volts positive. The PREPULSE SYNC OUT precedes the stimulus pulse as selected by the variable delay. The PULSE SYNC OUT occurs at the end of the delay period which is coincident with the onset of the stimulus pulse.

SYNCHRONOUS INPUT preferred is a positive pulse (with no negative overshoot) of 15 - 50 volts duration not greater than 50 microseconds. A CONTACTOR INPUT is provided so the SD9 may be synchronized with mechanical contacts such as are in the GRASS recording camera.

OUTPUT VOLTAGE ISOLATION CIRCUIT is built in to allow recording with the stimulator at the preparation site with minimum artifact. Output voltage is not referred to ground. An output polarity switch is included. Output impedance is equal to or less than 1 K ohm.

BIPHASIC PULSES can be derived from the monophasic pulses thereby reducing electrode polarization due to ion movement since positive and negative energy are equal.

SIGNAL MARKER CONTROL is possible via a two-contact female Jones #302 connector at the side of the SD9 chassis. The contacts are closed when the MODE switch is in the REPEAT or SINGLE position. The relay contacts will follow rates up to approximately 30 pulses per second. If the S9, SM9, or SD9 is to be used with a signal marker other than the Grass Polygraph, additional circuitry must be included to power the Signal Magnet. The SM9 circuit can be installed in the field as well as at the time of purchase.

NEON MONITOR LAMP flashes with each stimulus pulse.

TERMINALS will accept bare wires, phone tips or single or dual banana plugs.

DIAL accuracy is ± 5% or better for all parameters except VOLTS which is ± 10%.

MAXIMUM POWER is 30 watts at 115 volts, 50 - 60 cycles. TYPICAL POWER is 5 watts.

DIMENSIONS: Cabinet - 5-1/4" H x 9-1/2" W x 5-1/2" D. NET WEIGHT: 6.5 lbs.

Specifications subject to change without notice.

101 OLD COLONY AVENUE
QUINCY, MASS. 02169

617-773-0002

SERVICE

--HERE'S WHAT TO DO--

FOR INFORMATION PHONE OR WRITE:

"INSTRUMENT SALES"	for catalogs, ordering, delivery, and instrument applications.
"CUSTOMER SERVICE"	for trouble shooting advice, repair and replacement service.
"CHART PAPER SALES"	for recording chart paper.
"SUPPLY DEPARTMENT"	for electrodes, electrode cream, ink, pens, tubes, and other expendables.

DELIVERY OF YOUR GRASS INSTRUMENT IS NOT THE END - - - - BUT THE BEGINNING.

--OUR WARRANTY IS FOR TWO YEARS--

WE HAVE PROMPT EFFICIENT FACTORY SERVICE TO BACK IT UP.

However, our warranty does not cover transportation costs if repairs become necessary. Many universities and hospitals have Purchasing and Receiving Departments that must be informed. A PURCHASE ORDER NUMBER OR AUTHORIZATION IS NECESSARY. Therefore, we urge you to contact them before contacting us.

IF, "Instrument was damaged in transit" . . . .

a. Save packing materials for inspection by carrier's agent,

b. Obtain a joint inspection report from the carrier who delivered the instrument,

c. Report full details immediately to Grass Instrument Company.

IF, "It doesn't work" . . . .

a. We can ADVISE a solution to your problem but we need all the facts, including model and serial number of the instrument and symptoms of instrument malfunction. If possible, phone from a location near the instrument.

b. We can REPLACE damaged or defective units.

c. We can often send a STANDBY unit while yours is returned and repaired.

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MODEL S9 AND SD9 STIMULATORS

CONTENTS

SECTION 1 WARRANTY
SPECIFICATIONS
SERVICE POLICY

SECTION 2 GENERAL INFORMATION

SECTION 3 CONTROLS
- 3.1 Frequency - Pulses Per Second (PPS)
- 3.2 Delay (SD9 Only)
- 3.3 Duration
- 3.4 Voltage
- 3.5 Stimulus Selector Switches
- 3.6 Output Switch
- 3.7 Polarity Switch

SECTION 4 SYNCHRONOUS INPUTS AND OUTPUTS
- 4.1 Sync In - Synchronizing the S9 or SD9 with Other Instruments
- 4.2 Sync Out - Synchronizing Other Instruments with the S9 or SD9
- 4.3 CRO Sweep Synchronization
- 4.4 Driving the S9 or SD9 from the Grass C4 Kymograph Camera
- 4.5 Signal Marker Operation

SECTION 5 STIMULUS ISOLATION
- 5.1 Reduction of Stimulus Artifacts
- 5.2 Stimulus Current Monitoring

SECTION 6 PULSE WAVE FORMS (MODULATION)
- 6.1 Trains of Pulses
- 6.2 Pairs of Pulses
- 6.3 Twin Pulses (SD9 Only)

SECTION 7 CALIBRATION

SECTION 8 TROUBLE SHOOTING
- 8.1 General
- 8.2 Precautions
- 8.3 Procedure
- 8.4 Replacement of a Printed Circuit Board

SECTION 9 CIRCUITS

SECTION 2

GENERAL INFORMATION

2.1 DESCRIPTION

2.11 The SD9 is an economical solid-state stimulator designed for student and limited research applications where built-in stimulus isolation is more important than the expanded parameters of the S44, S48 and S88 series and remote stimulus isolation is not required. Routinely, the SD9 may be used in student labs for classical nerve and/or muscle stimulation and in operating room where the built-in isolation unit permits direct and safe patient stimulation. The SD9 replaces the SD5, yet remains compatible with it as well as with other Grass Stimulators.

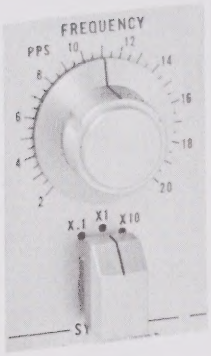
2.12 The only difference between the S9 and SD9 is that the SD9 has a delay circuit. Delay can be obtained from the S9 only if it is driven from an external source which contains a delay circuit. The printed circuits in both the S9 and the SD9 provide operational stability and rapid field service. A regulated power supply ensures constant parameter accuracy for normal fluctuations in line voltage.

2.13 The SD9 or S9 can be driven from an external source if frequencies outside the normal ranges of the SD9 or S9 are desired. Frequency is then controlled from the external source and delay (SD9 only), duration and voltage by the SD9 or S9. Conversely, the SD9 may be used to drive other instruments. Biphasic pulses and/or trains of pulses may be obtained from two SD9's or from an SD9 in combination with an S44, S48 or S88. Three SD9's are required to obtain post train pulses.

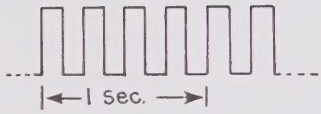
SECTION 3

CONTROLS

3.1 FREQUENCY - PULSES PER SECOND (PPS)

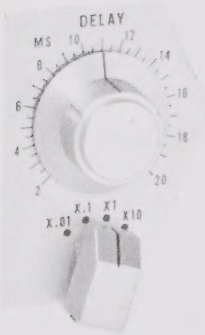


3.11 The FREQUENCY controls determine the number of pulses delivered per second in the repetitive mode. The repetition rate of pulses (from 0.2 to 200 PPS) is regulated by the variable potentiometer and a three decade switch directly beneath it. The number of pulses per second (PPS) is equal to the reading on the FREQUENCY dial multiplied by the setting of the decade switch. With the decade switch on X.1, a frequency range of from 0.2 to 2 PPS can be obtained; On the X1 position, from 2 to 20 PPS can be obtained; on the X10 position, from 20 to 200 PPS may be selected.

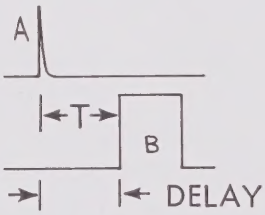


4 PPS

3.2 DELAY (SD9 ONLY)



3.21 The DELAY controls determine the time (T) between the sync out pulse (A) and the delivery of the leading edge of the pulse (B).



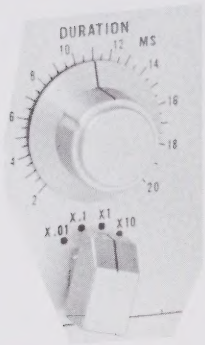
The SD9 has a variable delay function between the synchronous output pulse and the stimulus pulse. DELAY may be also used to set the refractory time interval for TWIN PULSE PAIR operation. (See Section 6.3.) The S9 does not have a pulse delay feature.

3.22 Delay times of .02 to 200 MS are selectable by the variable DELAY potentiometer and a 4 decade switch directly beneath it. The delay time in milliseconds is equal to the reading of the DELAY dial times the setting on the decade switch. With the decade switch at X.01, from .02 to .2 MS delay is available; at X.1, from 0.2 to 2 MS delay; at X1, from 2 to 20 MS; at X10, from 20 to 200 MS is available.

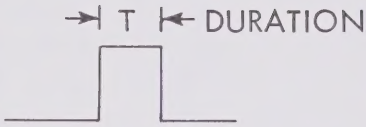
3.23 When using the repetitive pulses, the delay time should not exceed 50% of the period between pulses. The period between pulses (T) in seconds is the reciprocal of the frequency F (PPS) in pulses per second.

$$T = \frac{1}{F}$$

3.3 DURATION

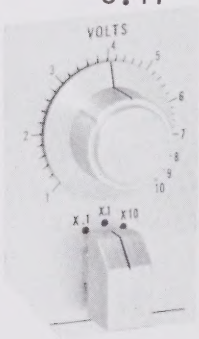


3.31 The DURATION controls determine the length of time (T) a pulse of given frequency and voltage appears on a CRO sweep or is delivered to a preparation. The pulse durations are variable from .02 MS to 200 MS and are determined by the variable DURATION potentiometer and a 4 decade switch directly beneath it. A given pulse duration is read by multiplying the DURATION dial reading by the decade switch position. On the X.01 position, from 0.02 to 0.2 MS duration is available; on X.1, from 0.2 to 2 MS; on X1, from 2 to 20 MS; on X10, from 20 to 200 MS.



3.32 When using repetitive pulses, the pulse duration setting should not exceed 50% of the interval between pulses.

3.4 VOLTAGE



3.41 The output voltage is controlled from 0.1 to 100 volts with the variable VOLTS potentiometer and the decade X.1, X1, X10 switch directly beneath it. The volts out is essentially the reading on the VOLTS dial multiplied by the setting of the decade switch with electrode impedances above 10 KΩ. With lower impedance electrodes, the electrode voltage will be lower than indicated.

The X.1 scale yields from 0.1 to 1 volts out; The X1 scale yields from 1 to 10 volts; X10 scale yields from 10 to 100 volts out.

3.42 Prior to stimulation, set the VOLTS decade switch to X.1 and VOLTS dial at 1. When ready to stimulate, gradually increase voltage until the desired threshold level is reached. If the threshold level is approached from the high voltage side, the preparation may be traumatized by excessively high currents.

3.43 The OUTPUT IMPEDANCE of the S9 and SD9 is less than 1 K ohm on any volts decade and is constant regardless of the setting of the VOLTS potentiometer. If the electrode impedance is low or if a more "constant current" source is desired, a high value of resistance may be added in series with the electrode, provided there is still sufficient voltage from the SD9 to stimulate the preparation. To satisfy the conditions of a "constant current" source, the added series resistance should be at least 5 or 10 times the electrode impedance.

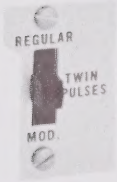
3.44 The monitor lamp flashes with each stimulus pulse and remains on only during the duration of the pulse. It is independent of the voltage controls. Pulses of short duration may be difficult to see in room light.

3.5 STIMULUS SELECTOR SWITCHES

3.51 The MODE lever switch selects between REPEAT-OFF-SINGLE pulses. In the REPEAT (up) position, repetitive pulses are delivered at a rate indicated by the FREQUENCY dial and will continue to be delivered until the lever switch is returned to the OFF (mid) position.

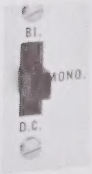
3.52 A single pulse is produced when the MODE switch is depressed to the SINGLE position. The MODE switch is spring loaded in the SINGLE position and must be manually depressed for each pulse and will return to the OFF position as soon as finger is released.

3.53 A set of contacts on the MODE switch are wired to a two-contact female connector labeled SIGNAL MARKER which is located on the side of the SD9 or S9 panel. These contacts close when the MODE switch is in either the SINGLE or REPEAT position and may be used to operate a signal magnet. The contacts are rated for 1 ampere.



3.54 The 3-position slide switch on the SD9 or 2-position slide switch on the S9 to the left of the MODE switch determines whether the stimulator is driven by its internal circuitry or from an external source. In the REGULAR position, the S9 or SD9 will generate either repetitive or single pulses as determined by the MODE switch. In the TWIN PULSE position (SD9 only), either repetitive or single twin pulse pairs will be produced as determined by the MODE switch. The first pulse of the twin pulse pair will be coincident with the start of the CRO sweep (and also the prepulse) and the second pulse will appear as determined by the setting of the DELAY controls. The amplitude and duration of the pulses will always be identical. Twin pulses are not available from the S9. In the MOD position, trains of pulses may be obtained by modulating the S9 or SD9 via the MOD IN binding post with the output of another stimulator (see Section 6.1).

3.6 OUTPUT SWITCH



3.61 The OUTPUT switch selects monophasic pulses, biphasic pulses or DC voltage. The output wave forms obtained in the MONO (monophasic) and BI (biphasic) positions of the OUTPUT switch are shown in Figure 3.61. In the BI position, a capacitor is in series with the output. This minimizes the electrode polarization due to ion movement, since it tends to equalize the positive and negative stimulus energies. During long periods of stimulation as when stimulating through implanted electrodes, a biphasic stimulus helps reduce the formation of gas bubbles and electrolytic deposition.

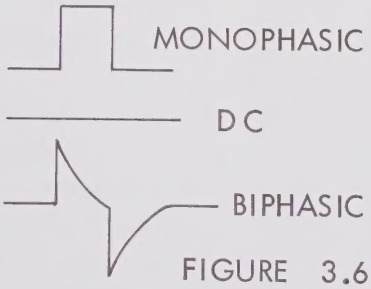


FIGURE 3.61

3.62 The D C voltage obtained at the output terminals when the OUTPUT switch is in the D C position is present as long as the MODE switch is maintained in either the SINGLE or REPEAT position.

3.7 POLARITY SWITCH

3.71 In the NORMAL position, the Red (+) output binding post is positive with respect to the Black binding post.

In the REVERSE position, the Red binding post is negative with respect to the black binding post.

EXAMPLE OF SQUARE WAVE IN NORMAL AND REVERSE POLARITY POSITIONS.

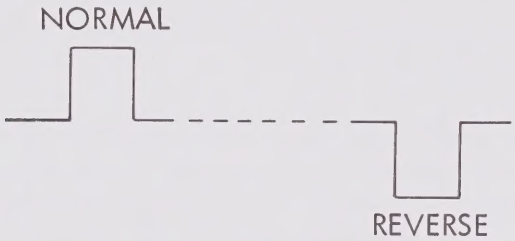


FIGURE 3.72

SECTION 4

SYNCHRONOUS INPUTS AND OUTPUTS

4.1 SYNC IN - SYNCHRONIZING THE S9 OR SD9 WITH OTHER INSTRUMENTS

4.11 The Grey SYNC IN trigger binding post enables the S9 or SD9 to be triggered by a positive pulse between 15 and 50 volts, and not more than 50 microseconds duration.

4.12 The Violet MOD binding post permits external modulation of an SD9. This can be accomplished by introducing a positive voltage between 10 and 150 volts at the MOD IN binding post with the REGULAR-TWIN PULSES-MOD slide switch in the MOD position and the MODE switch in the REPEAT position. Pulses will be delivered from the SD9 as long as this voltage is maintained at the MOD IN binding post. When the output voltage from any Grass Stimulator is applied, repeating trains of pulses at prescribed rates can be obtained. (See Section 6.11.)

4.13 EXTERNAL CONTROL from a pair of external contacts (switch, relay contacts, commutator contacts, etc.) will generate one stimulus pulse for each closure of the contacts. Operating from external contacts is functionally the same as operating the MODE switch in the SINGLE position. Repetitive pulses utilizing the FREQUENCY circuit cannot be generated with the contactor operation and the MODE switch must be left in the OFF position. The EXTERNAL SINGLE input (so labeled) is a two contact receptacle located on the side of the panel. The mating connector is a Jones P302CCT. To operate the SD9 from a pair of external contacts, connect two leads from a pair of normally open contacts to the two contacts in the EXTERNAL SINGLE plug. Do not connect either of the EXTERNAL SINGLE contacts to ground or to any circuit other than the isolated contacts to be used for control.

4.2 SYNC OUT - SYNCHRONIZING OTHER INSTRUMENTS WITH THE S9 OR SD9

4.21 The SYNCHRONOUS OUTPUT pulses are approximately 35 volts positive with an output impedance of approximately 300 ohms. The PREPULSE SYNC OUT (SD9 only) preceeds the stimulus pulse as selected by the variable delay. This pulse is coincident with the output of the FREQUENCY circuit and the start of the DELAY pulse as shown in Figure 4.22 and is used primarily to synchronize the sweep of the CRO cathode ray oscilloscope. The PREPULSE SYNC OUT is available from the Green binding post.

4.22 The SD9 PULSE SYNC OUT occurs at the end of the selected delay period which is coincident with the onset of the stimulus pulse. The S9 PULSE SYNC OUT is coincident with the onset of the stimulus pulse. See Figure 4.22. The primary use of the PULSE SYNC OUT is to drive another stimulator at its SYNC IN terminal (to get a simultaneous pulse with delivery of stimulus).

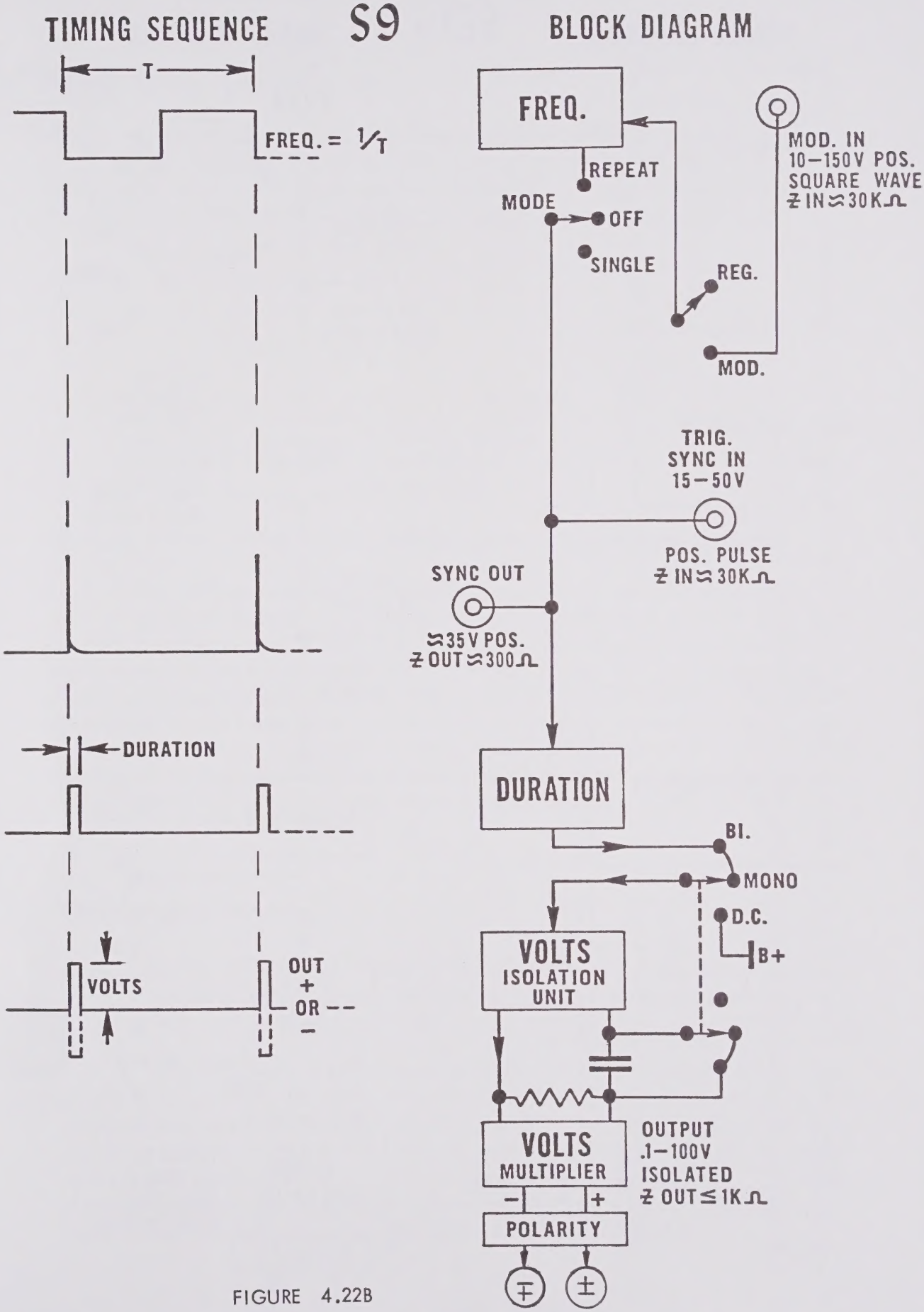
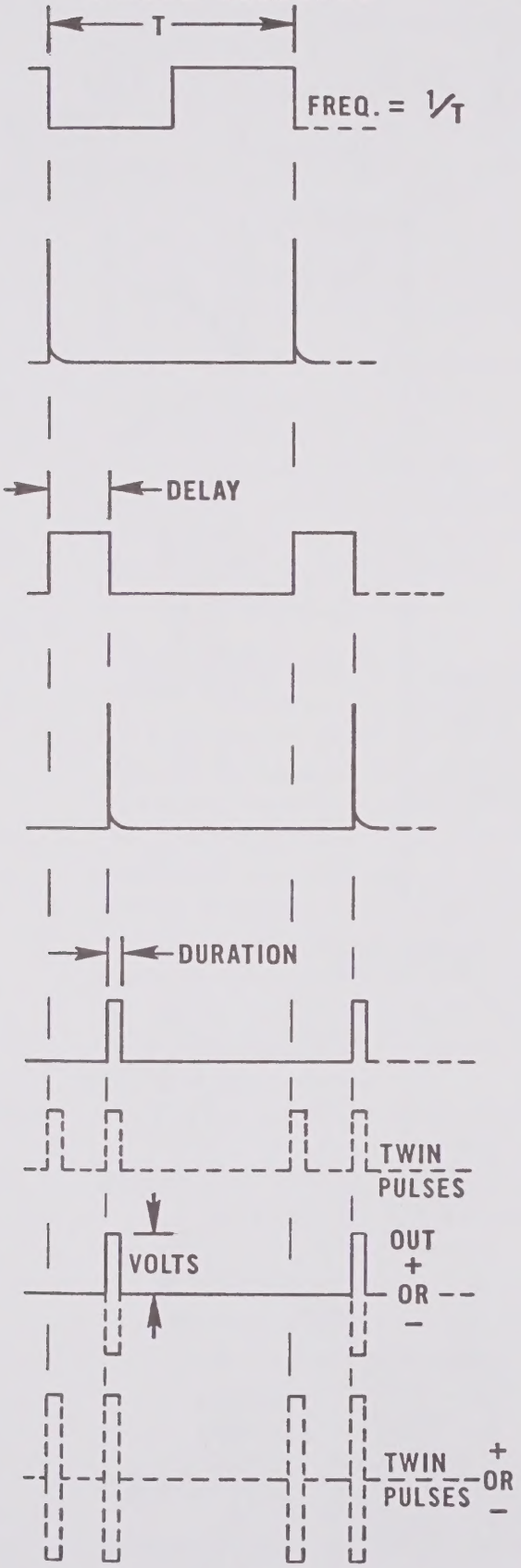

TIMING SEQUENCE
S9
BLOCK DIAGRAM
T
FREQ. = 1/T
DURATION
VOLTS
OUT
+
OR
−
FREQ.
REPEAT
MODE
OFF
SINGLE
REG.
MOD.
MOD. IN
10−150V POS.
SQUARE WAVE
Z IN ≈ 30K Ω
TRIG.
SYNC IN
15−50V
POS. PULSE
Z IN ≈ 30K Ω
SYNC OUT
≈ 35V POS.
Z OUT ≈ 300 Ω
DURATION
BI.
MONO
D.C.
B+
VOLTS
ISOLATION
UNIT
VOLTS
MULTIPLIER
OUTPUT
.1−100V
ISOLATED
Z OUT ≤ 1K Ω
−
+
POLARITY
∓
±

FIGURE 4.22B

SD9

TIMING SEQUENCE



BLOCK DIAGRAM

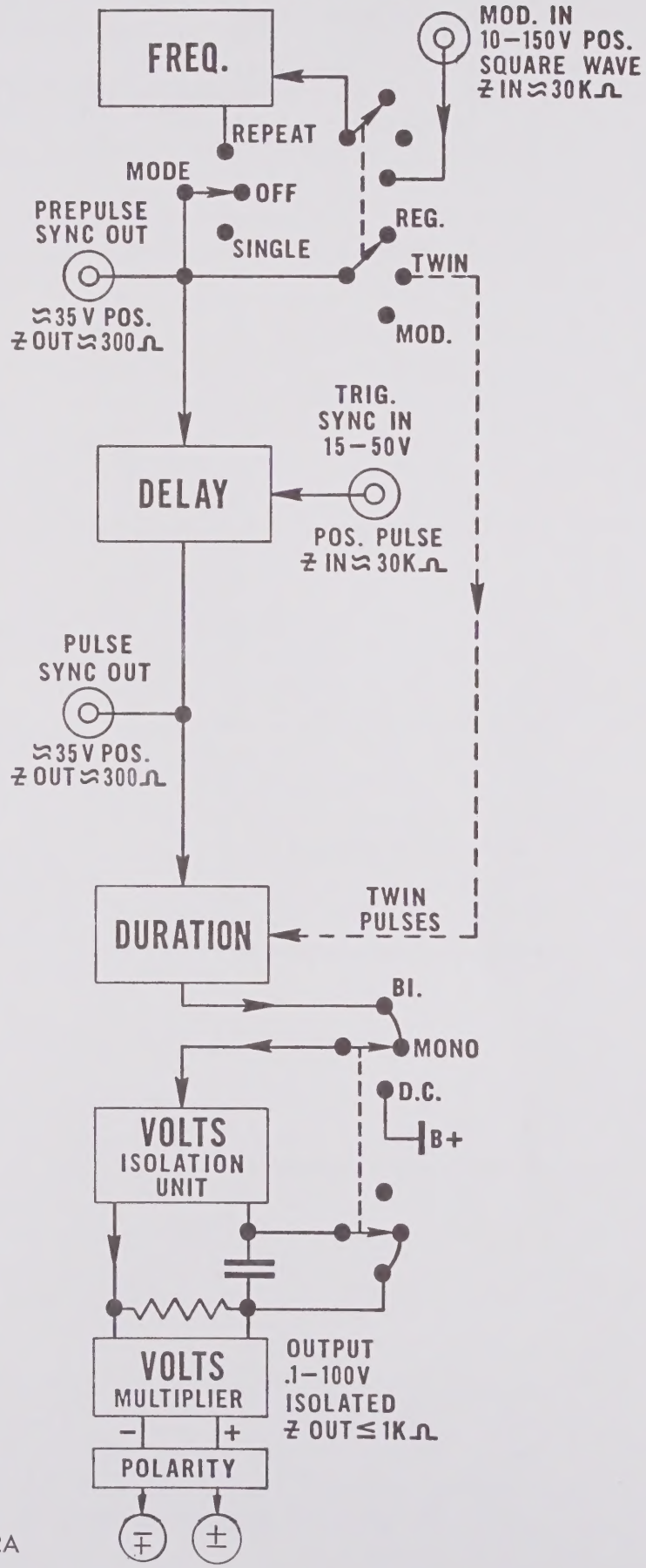


FIGURE 4.22A

4.3 CRO SWEEP SYNCHRONIZATION

4.31 Synchronization of the CRO sweep is accomplished by connecting a lead from the SYNC PREPULSE OUT terminal of the SD9 to the external synchronization or external trigger terminal of the CRO. Connect a lead between the ground (GND) terminal of the SD9 and the ground terminal of the CRO.

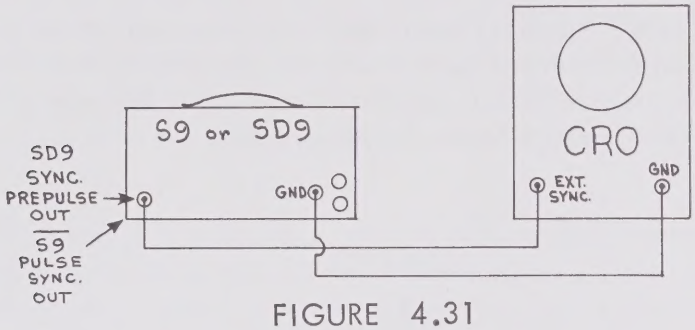


FIGURE 4.31

4.4 DRIVING THE S9 OR SD9 FROM THE GRASS C4 KYMOGRAPH CAMERA

4.41 The SD9 may be driven by the C4 Camera by connecting either the contactor or relay output of the C4 to the EXTERNAL SINGLE input of the SD9. (See Section 4.13.) It may also be driven by connecting the shutter output of the C4 to the SYNC IN terminal of the SD9. One stimulus pulse is generated for each closure of the contacts. In all instances, the ground terminals of the SD9 and the C4 should be connected. For further details, see Section 1 - Synchronous Outputs - of the C4 Manual and refer to the SYNCHRONIZING BLOCK DIAGRAMS which show the location of the various synchronizing outputs of the C4. (See Section 9, Synchronizing Outputs, in the C4 Manual.)

4.5 SIGNAL MARKER OPERATION

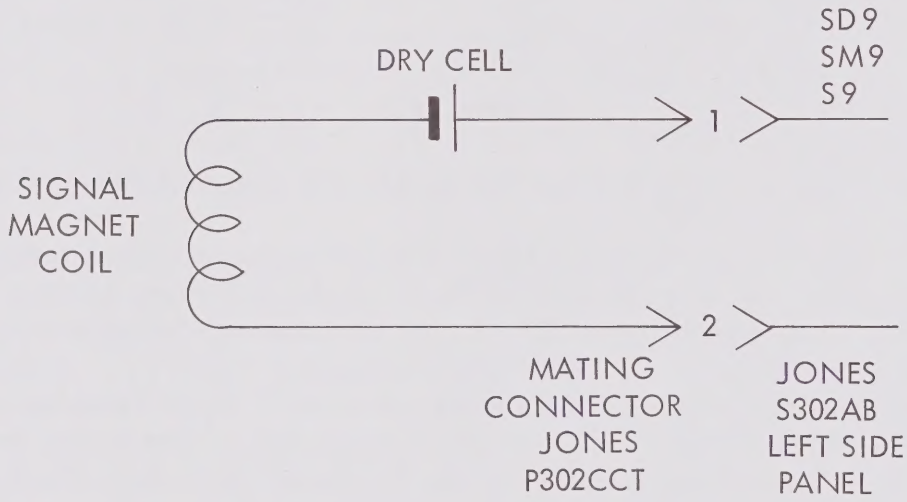
4.51 In the S9 and SD9, a pair of contacts are wired to the Jones connector #S302 labeled SIGNAL MARKER located on the left panel of the instrument. The mating connector is a Jones #P302CCT. See Circuit #50351.

SIGNAL MARKER

If the SIGNAL MARKER from the S9 or SD9 is connected to either the remote UP or DOWN connector of the Grass Polygraph SIGNAL MARKER, power is adequate to drive the SIGNAL MAGNET. With the MODE switch on the S9 or SD9 in the REPEAT or SINGLE position, contacts of the MODE switch will remain closed until the switch is returned to the OFF position. Thus, the signal marker pen will not deflect with each individual pulse; it will deflect once and remain deflected until the MODE switch is turned OFF.

4.52 In the SM9, a pair of relay contacts are wired to the Jones #S302 SIGNAL MARKER connector. These contacts open and close each time a stimulus pulse is generated at the SM9 output in both the REPEAT and SINGLE positions of the MODE switch. The relay contacts will follow rates up to approximately 30 pulses per second. At higher rates, the contacts remain closed for the duration of the volley. Contacts are rated at 2 amperes resistive load.

4.53 If the S9, SD9 or SM9 is to be used with a SIGNAL MARKER other than the Grass Polygraph, additional circuitry must be included to power the SIGNAL MAGNET. See Figure 4.53. If the S9, SD9 or SM9 is used with a Grass Polygraph, no additional circuitry is necessary because power for the SIGNAL MARKER is contained in the Polygraph.



SIGNAL MAGNET CIRCUIT
FIGURE 4.53

SECTION 5

STIMULUS ISOLATION

5.1 REDUCTION OF STIMULUS ARTIFACTS

5.11 The S9 and SD9 have built-in ground isolation circuits which work as follows. A pulse with the duration indicated by the DURATION dial modulates a Radio Frequency oscillator. The RF oscillator transformer is designed so that its secondary coil has low capacitance and conductance to ground. The secondary voltage is rectified and filtered. The output voltage stimulus is then nearly identical with the modulating pulse, but is isolated from ground.

5.12 This method is primarily useful to reduce artifacts due to ground currents between stimulating and recording systems via the preparation. It is also valuable as a safety device in isolating the stimulating electrodes from ground, thus providing greater safety for the subject, and in the operating room. Furthermore, it allows direct addition of stimuli of either algebraic sign without further consideration. It is not proposed as a cure-all for all stimulus artifact problems. For example, the artifact caused by the presence of the recording electrodes in a strong local field produced by the stimulus currents cannot be eliminated by any device since the recording electrodes measure the current in the stimulus field.

5.13 An intermediate situation is the case where a large volume surrounds the closely spaced stimulating electrodes, as in cortical stimulation. Here the stimulus current has a three dimensional field pattern which decreases with the cube of the distance from the electrodes. In recording from such a three dimensional mass it is very important to reduce ground currents, and the Stimulus Isolation Circuit does this job well. This is particularly necessary in the instances of multi-channel recording such as with the Electroencephalograph.

5.14 In some applications inserting equal resistances in series with both electrodes is effective in reducing ground current artifacts. Choose as high a resistance value as possible consistent with stimulus current requirements. Such series resistances can also be used to simulate constant current sources.

5.2 STIMULUS CURRENT MONITORING

5.21 Since the preferred description of electrical stimulus is in terms of stimulus current rather than voltage, it is often desirable to measure the actual stimulus current. When using a DC stimulus, current can be measured with a DC milliammeter connected in series with the stimulating electrodes. Stimulus isolation can be maintained as long as the meter is isolated from ground.

5.22 With square wave stimulation, peak stimulus current is determined by a Cathode Ray Oscilloscope (CRO) as a measurement of the square wave voltage across a series resistance whose value is very small compared to that of the stimulating electrodes. The current is calculated using Ohm's Law. However, stimulus isolation is lost using this method since the input of the CRO is referred to ground. If stimulus isolation must be maintained for the simultaneous recording of electrical responses, the best solution is to measure current periodically during the course of the experiment.. The circuit for intermittent measurement of stimulus current is shown in Figure 5.22. It is fairly safe to assume that the stimulus current has remained constant between two current measurements if the current is the same for both measurements, and the VOLTS controls have not been changed. If it is not necessary to maintain stimulus isolation, the double pole switch can be eliminated and current monitored continuously with one side of the CRO at ground potential. With the circuit shown in Figure 5.22, each milliamp of stimulus current will result in a voltage drop of 10 millivolts across the 10 ohm resistor. Calibrate the CRO for a sensitivity of 10 MV/CM. The CRO deflection can be measured in terms of stimulus current, each centimeter of deflection indicating 1 milliamp of stimulus current.

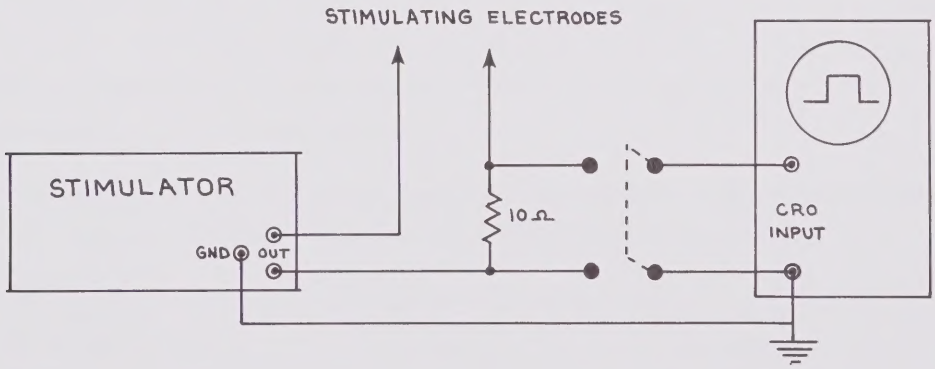


FIGURE 5.22 MEASURING STIMULUS CURRENT

SECTION 6

PULSE WAVE FORMS

6.1 TRAINS OF PULSES - (MODULATION)

6.11 The output of an S9, S44 or another SD9 may be used to modulate (turn on and off at prescribed intervals) the pulse output of an SD9. An SD9 may also be used to modulate an S9. A typical set-up and the resulting stimulus pattern is shown in Figure 6.11.

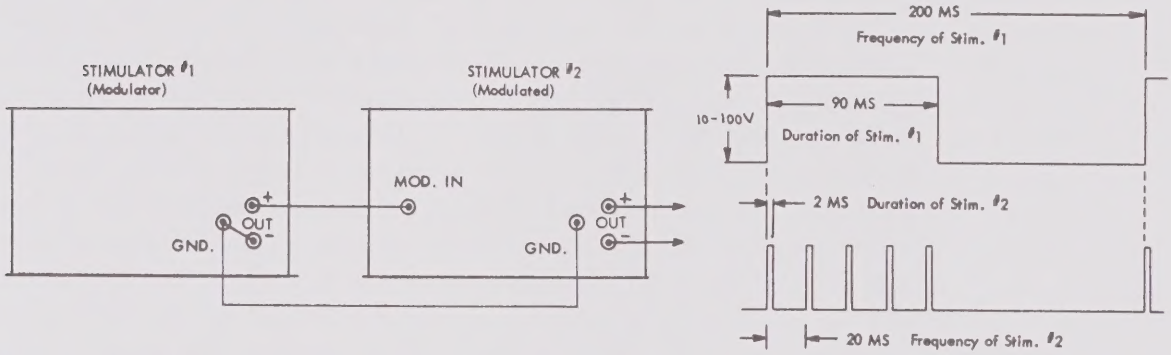


FIGURE 6.11 TRAINS OF PULSES

6.12 To obtain a train of pulses five times a second with the stimulus parameters shown in Figure 6.11, the control settings of the two SD9 stimulators (only) would be as follows:

CONTROL	STIMULATOR #1 (Modulating)	STIMULATOR #2 (Modulated)
MODE	REPEAT	REPEAT
STIMULUS SELECTOR	REGULAR	MOD
FREQUENCY	5 Pulses/sec.	50 Pulses/sec.
DELAY	.2 MS	.2 MS
DURATION	90 MS	2 MS
VOLTS	10 - 100V	As Desired
OUTPUT	MONO	MONO
POLARITY	NORMAL	NORMAL

In the above instances, five 2 MS pulses are produced five times a second. The DURATION of Stimulator #1 is set at 90 MS, Stimulator #2 is turned off 10 MS after the fifth pulse. If it were set at exactly 80 or exactly 100, there is a possibility the fifth pulse might be lost with a setting of 80 MS and of a sixth pulse occurring with a setting of 100 MS. When setting up the stimulators for modulation, monitor the output of Stimulator #2 to be certain the output is the desired one. If the last pulse does not appear on every sweep, increase the DURATION of Stimulator #1 slightly to include the intermittent pulse, or decrease the DURATION slightly to eliminate it.

6.2 PAIRS OF PULSES

6.21 PAIRS OF PULSES with a variable interval between pulses and independent control of the parameters of each pulse are obtained by driving one SD9 with the appropriate SYNC OUT pulse of another SD9 (or by the appropriate SYNC OUT pulses of an S44, or S48 stimulator). As shown in Figure 6.21, a lead is connected between the SYNC OUT PULSE terminal of the driving stimulator and the SYNC IN terminal of the driven stimulator. A grounding lead is connected between the GND (ground) terminals of the two stimulators. The stimulus pulses should be monitored on a CRO before connecting the stimulating electrodes to make sure that the wave form obtained is the desired one.

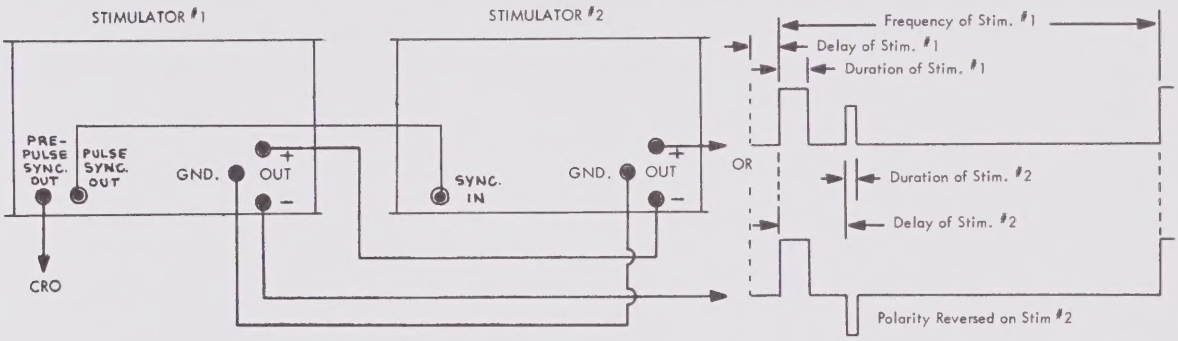


FIGURE 6.21 PAIRS OF UNLIKE PULSES

6.22 ADDITION OF THE OUTPUTS of two Grass stimulators having outputs isolated from ground (Models S9, SD9 and Models S44, S48 or S88 with a Model SIU5 Stimulus Isolation Unit) may be combined to stimulate through a single pair of electrodes. The outputs should be connected in series for this purpose.

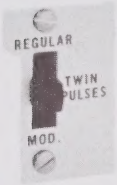
6.23 The parameters of the two pulses are independent and are determined by the control settings of the two stimulators.

6.24 The interval between pulses is set with the DELAY control of the driven stimulator.

6.25 When repetitive pulse pairs are generated the duration of each pulse and the interval between pulses should not exceed one-half the period of the repetition rate. (e.g., if the FREQUENCY controls of the driving stimulator are set for 10 pulses per second, the period is 100 milliseconds.) Therefore, the duration of each pulse and the delay setting of the driven stimulator should not exceed 50 milliseconds.

6.3 TWIN PULSES (SD9 ONLY)

6.31 The TWIN PULSE position of the REGULAR-TWIN PULSE-MOD slide switch is included so that two pulses of identical voltage and duration can be obtained from one SD9 for nerve and muscle refractory time studies. The time between the first and second twin pulse will be indicated by the delay controls. To establish refractory time, start with a low frequency and an excessively long delay time between twin pulses to assure full response for each stimulus. Gradually reduce the delay time until there is first intermittent, then no response to the second pulse. Refractory time is established at the time when response disappears, not when it reappears again after extending the delay time between pulses. Read the refractory time from the DELAY controls.



SECTION 7

CALIBRATION

7.1 GENERAL INFORMATION

7.11 The FREQUENCY, DELAY and DURATION circuits are calibrated at the factory for an accuracy of ± 5%. The output voltage (VOLTS) circuit is calibrated for an accuracy of ± 10%. The FREQUENCY, DELAY, DURATION and VOLTAGE readings will not vary appreciably for line voltage variations between the range of 105 to 130 volts AC.

7.12 Calibration should not shift unless the potentiometers on the printed circuit boards are accidentally turned. If calibration is required for any reason, contact Grass Instrument Company for instructions.

SECTION 8

TROUBLE SHOOTING

8.1 GENERAL

8.11 There are five plug-in printed circuit boards in the SD9 stimulator and four in the S9, each containing components for a specific circuit function. There is a board associated with the frequency, delay (SD9 only), duration, output voltage and power supply circuitry.

8.12 Calibration of the timing and output boards is, of course, factory adjusted and should not require recalibration even if a replacement board is necessary. However, if for some reason the calibration is not found to be within specifications, request a replacement board.

8.2 PRECAUTIONS

8.21 Be certain that the dials and multiplier switches are set not to exceed 50% duty cycle during trouble shooting.

8.22 Since the rise time of the S9 and SD9 sync pulses are very fast (less than 50 NS), the maximum amplitude of the pulses may not be observable if the oscilloscope being used does not have a wide enough frequency response; however, most oscilloscopes will probably indicate at least 25 volts.

8.3 PROCEDURE

8.31 In the event of a malfunction in the SD9 stimulator, use the following procedure to isolate the trouble to a specific printed circuit board so that the proper replacement can be requested from Grass Instrument Company. (In the case of the S9 stimulator, there is only one SYNC OUT binding post which is Orange and labeled OUT, so eliminate Step b and consider the sync binding post according to Step a.)

a. If no pulses appear at the output terminals of the stimulator, check the PREPULSE (Green) binding post with an oscilloscope for the proper sync pulse. If the proper sync pulse appears here, proceed to Step b. If there is no sync pulse, remove the stimulator cover and check the voltage at the Red pin jack at the rear of the power supply board. If this voltage does not read 18 volts, this board is probably defective. If the 18 volts is correct, the trouble is probably in the frequency board.

b. Check the PULSE (Orange) binding post for the proper sync pulse. If this appears to be correct, proceed to Step c. If there is no sync pulse, the delay board is probably defective.

c. Slide the three position OUTPUT slide switch to the DC position. If the proper DC voltage appears at the output terminals and the monitor lamp operates properly, the output board is probably functioning properly and the defect is most likely in the duration board. If, however, no DC voltage appears at the output terminals in the DC position, the fault is probably in the output board.

8.32 If you are able to locate the defective board, contact Grass Instrument Company and request a replacement board. When it arrives, replace defective board (see Section 8.4) and return it to Grass Instrument Company. If you are unable to locate the defect, contact Grass Instrument Company. Perhaps a simple suggestion from us will lead you to the defect. If not, a replacement unit will be sent to you. Save its packing material to return the defective unit.

8.4 REPLACEMENT OF A PRINTED CIRCUIT BOARD

8.41 Both the printed circuit boards and their appropriate sockets are clearly labeled. See Figure 8.41 for SD9, or Figure 8.42 for S9. The stimulators are wired in such a way that if a printed circuit board is accidentally plugged into the wrong socket, there will be no damage to either circuit.

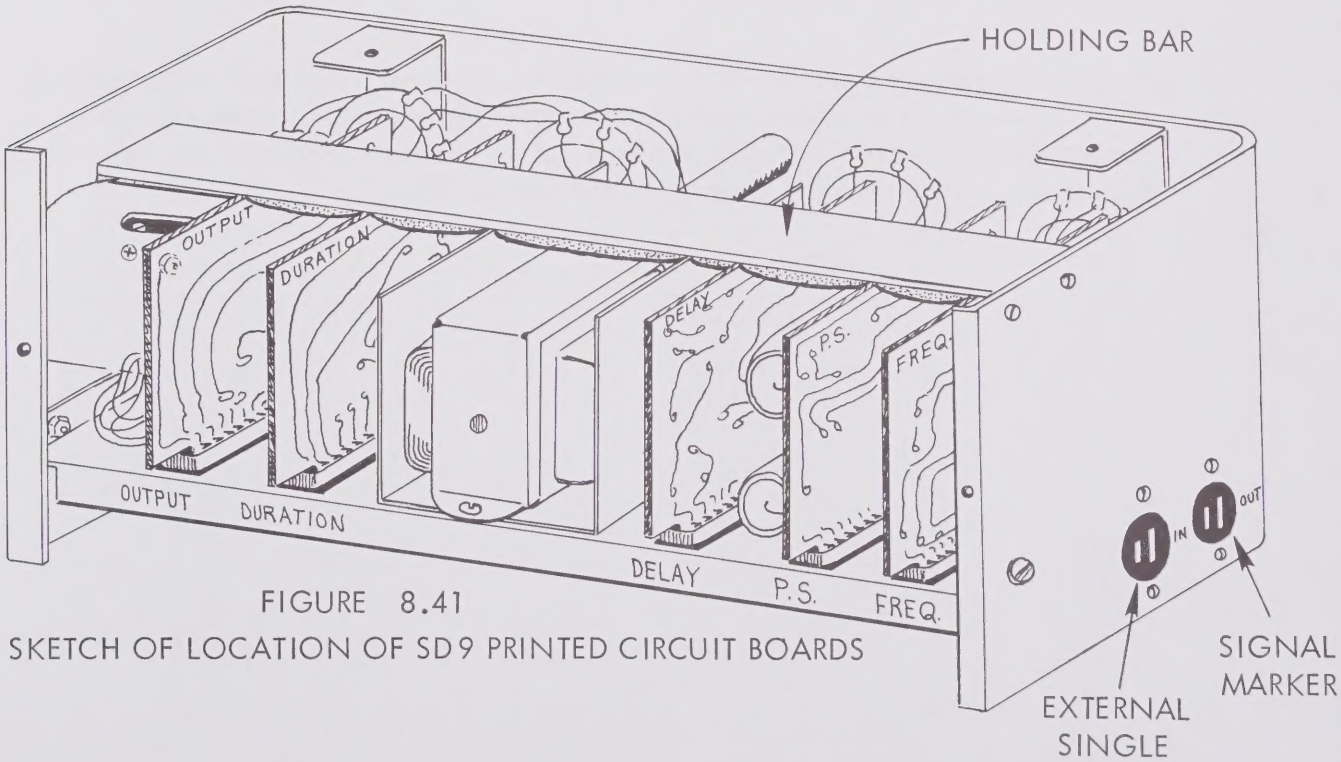


FIGURE 8.41
SKETCH OF LOCATION OF SD9 PRINTED CIRCUIT BOARDS

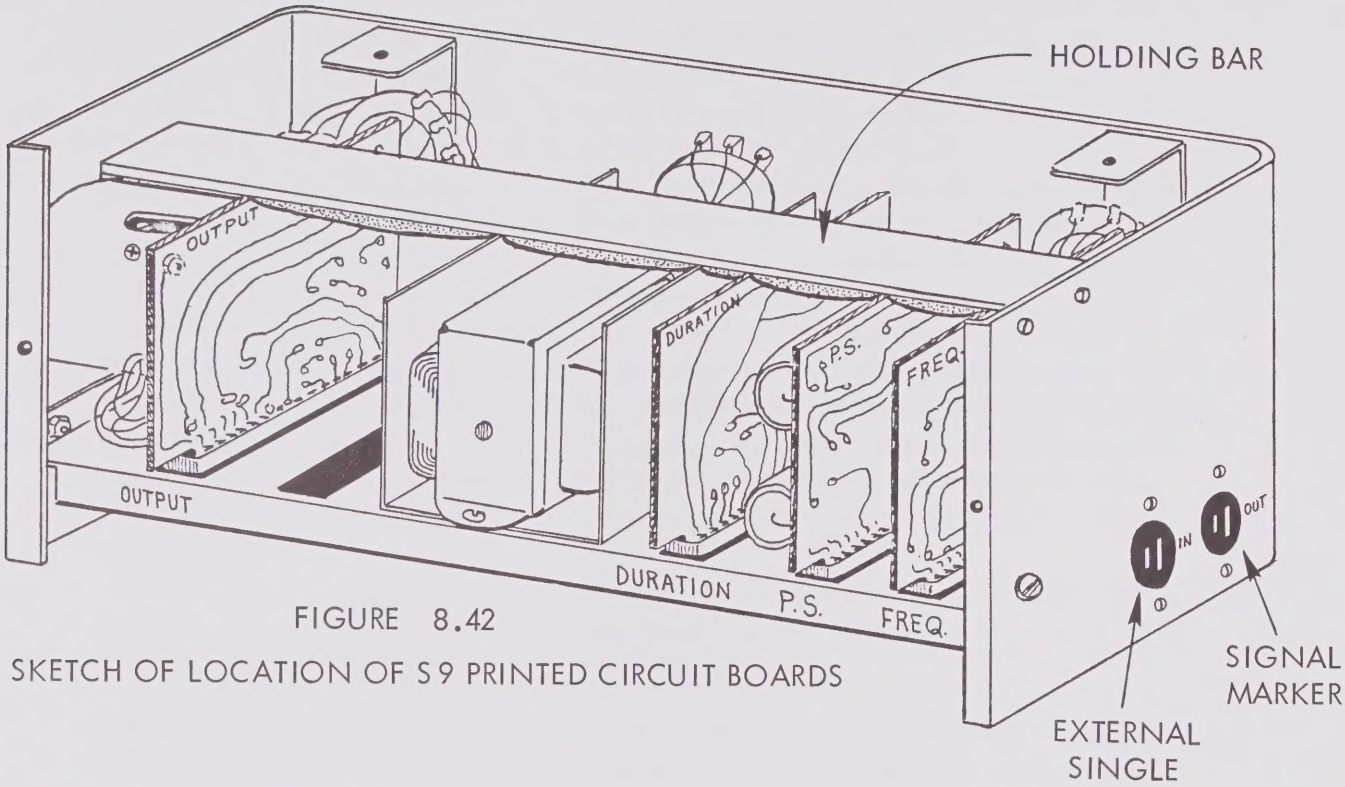
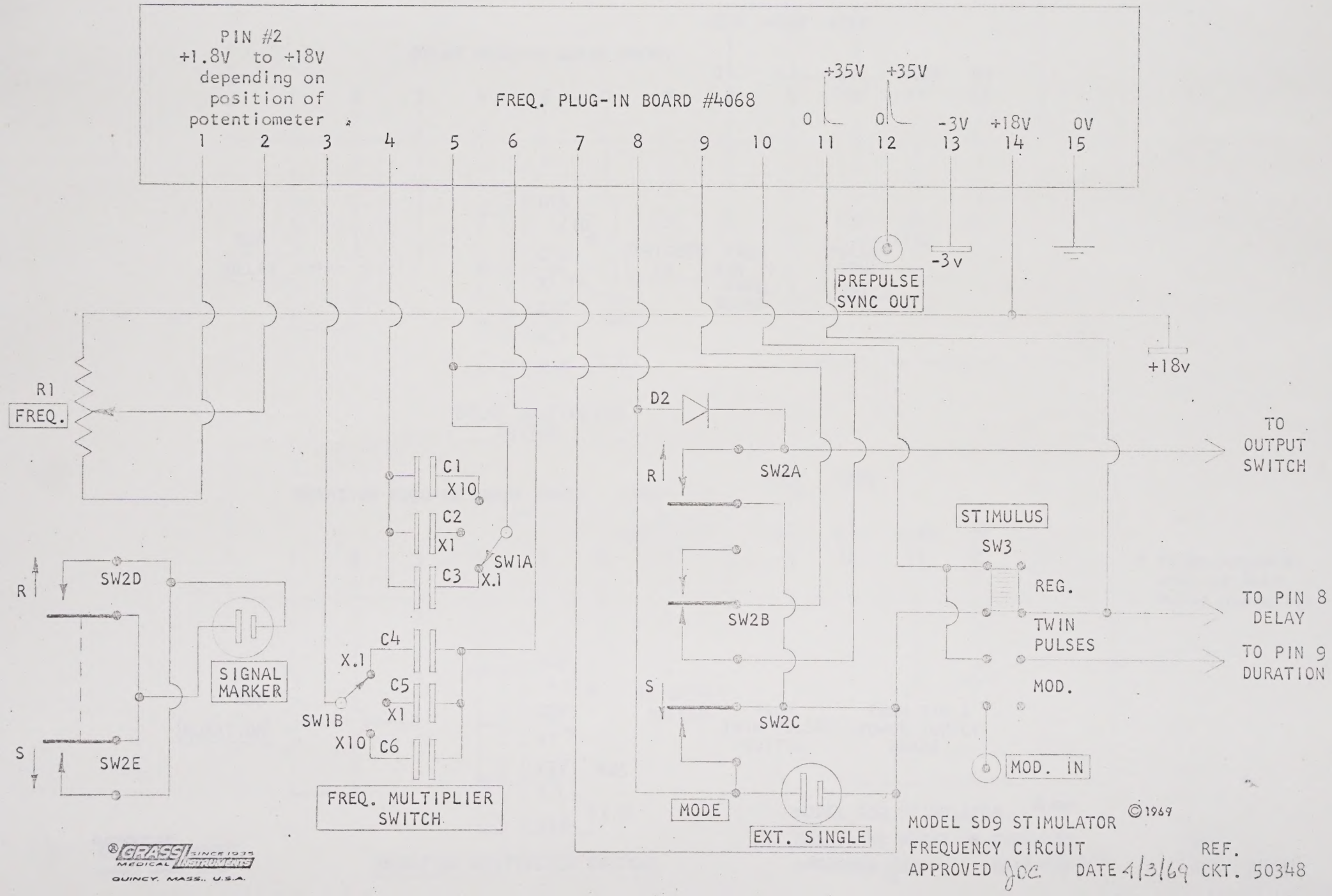
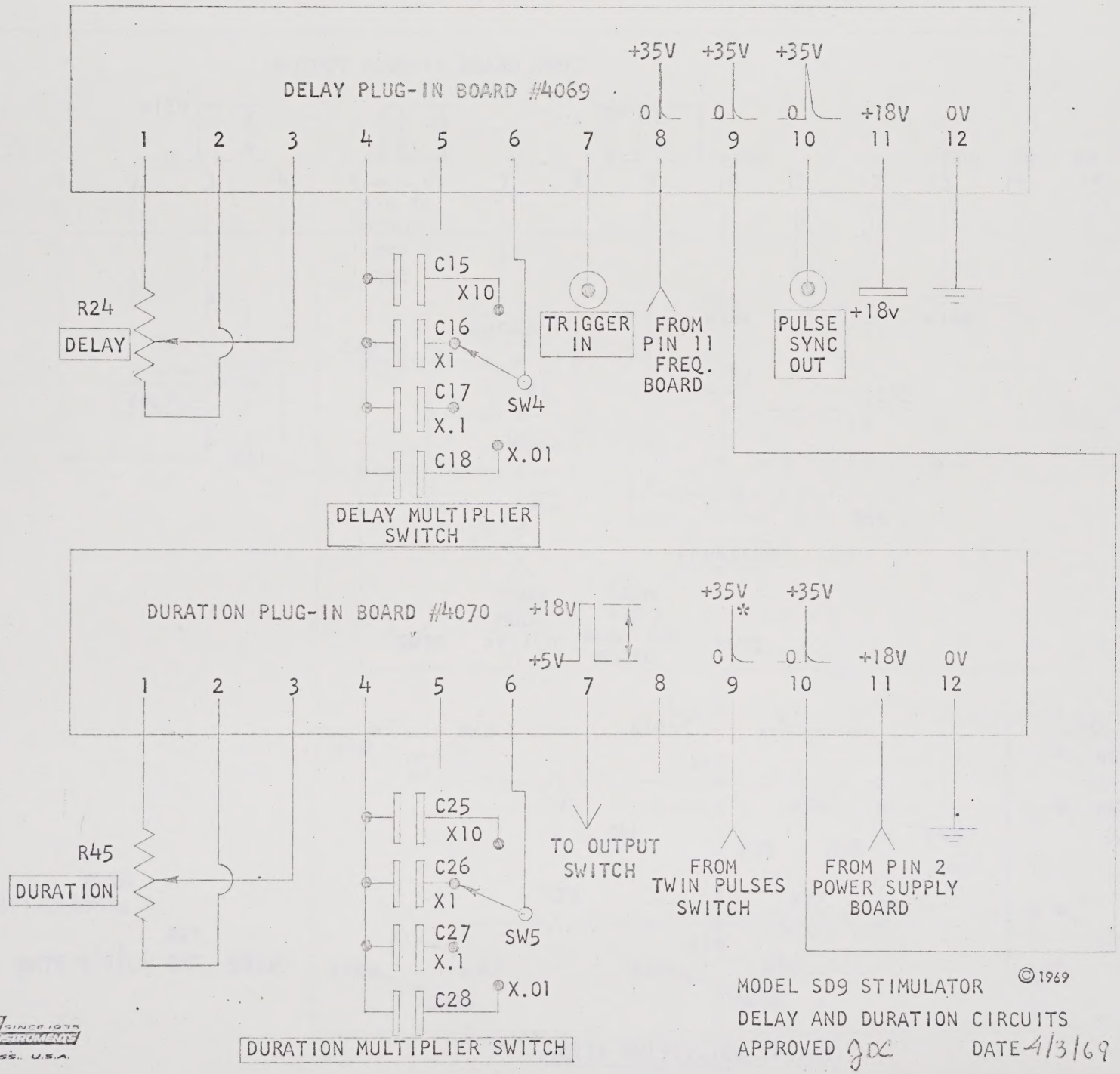


FIGURE 8.42

SKETCH OF LOCATION OF S9 PRINTED CIRCUIT BOARDS

8.42 To remove a printed circuit board, first remove the circuit board holding bar, then grasp the appropriate board with two fingers (avoid touching components or soldered contacts) and pull out. Reverse procedure for insertion. Each board will fit into the chassis in only one position.


PIN #2
+1.8V to +18V
depending on
position of
potentiometer
FREQ. PLUG-IN BOARD #4068
+35V
+35V
0
0
-3V
+18V
0V
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
-3v
PREPULSE
SYNC OUT
+18v
R1
FREQ.
D2
TO
OUTPUT
SWITCH
C1
X10
C2
X1
SW1A
C3
X.1
R
SW2A
STIMULUS
SW3
REG.
TWIN
PULSES
MOD.
TO PIN 8
DELAY
TO PIN 9
DURATION
SW2B
SW2C
S
MOD. IN
MODE
EXT. SINGLE
R
SW2D
SIGNAL
MARKER
S
SW2E
C4
X.1
C5
X1
SW1B
X10
C6
FREQ. MULTIPLIER
SWITCH
GRASS MEDICAL INSTRUMENTS
SINCE 1935
QUINCY, MASS., U.S.A.
MODEL SD9 STIMULATOR
©1969
FREQUENCY CIRCUIT
REF.
APPROVED JOC.
DATE 4/3/69
CKT. 50348



* Pulse appears only in Twin Pulse Operation

MODEL SD9 STIMULATOR ©1969

DELAY AND DURATION CIRCUITS

APPROVED gdc DATE 4/3/69

REF. CKT. 50349

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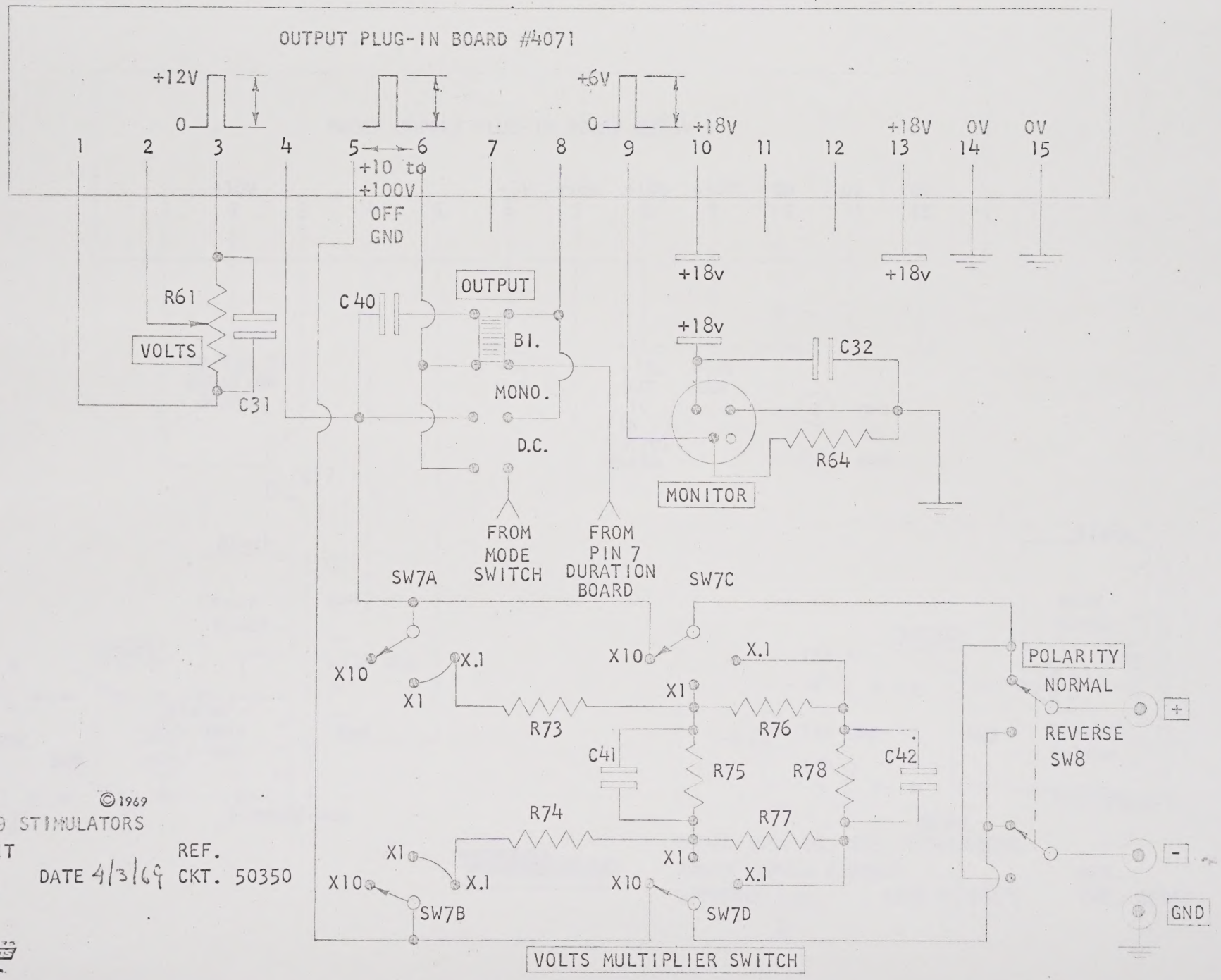
QUINCY, MASS., U.S.A.



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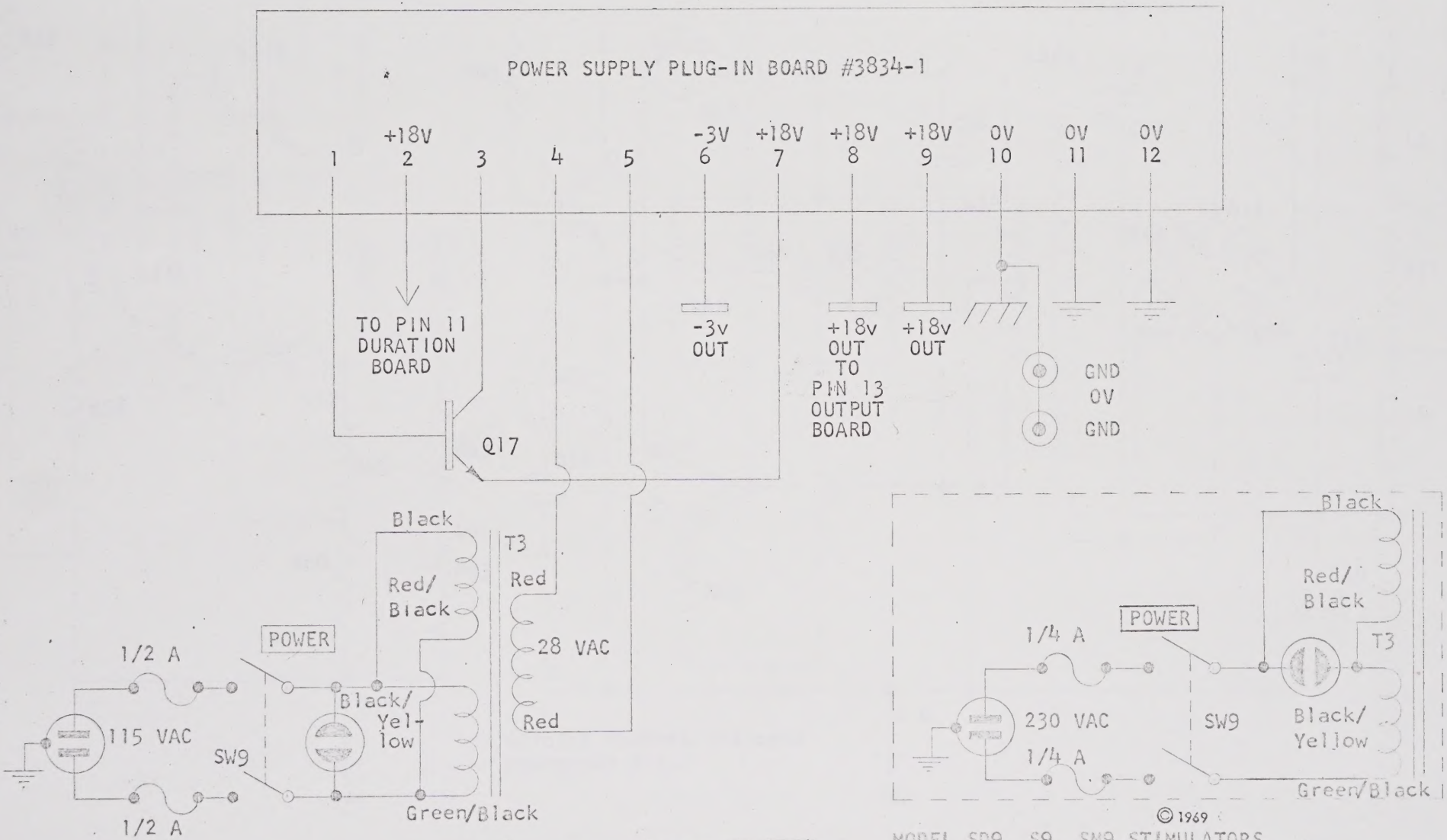
MODEL S9, SD9 STIMULATORS

OUTPUT CIRCUIT

APPROVED Joe DATE 4/3/69 REF. CKT. 50350

GRASS MEDICAL INSTRUMENTS SINCE 1935
QUINCY, MASS., U.S.A.



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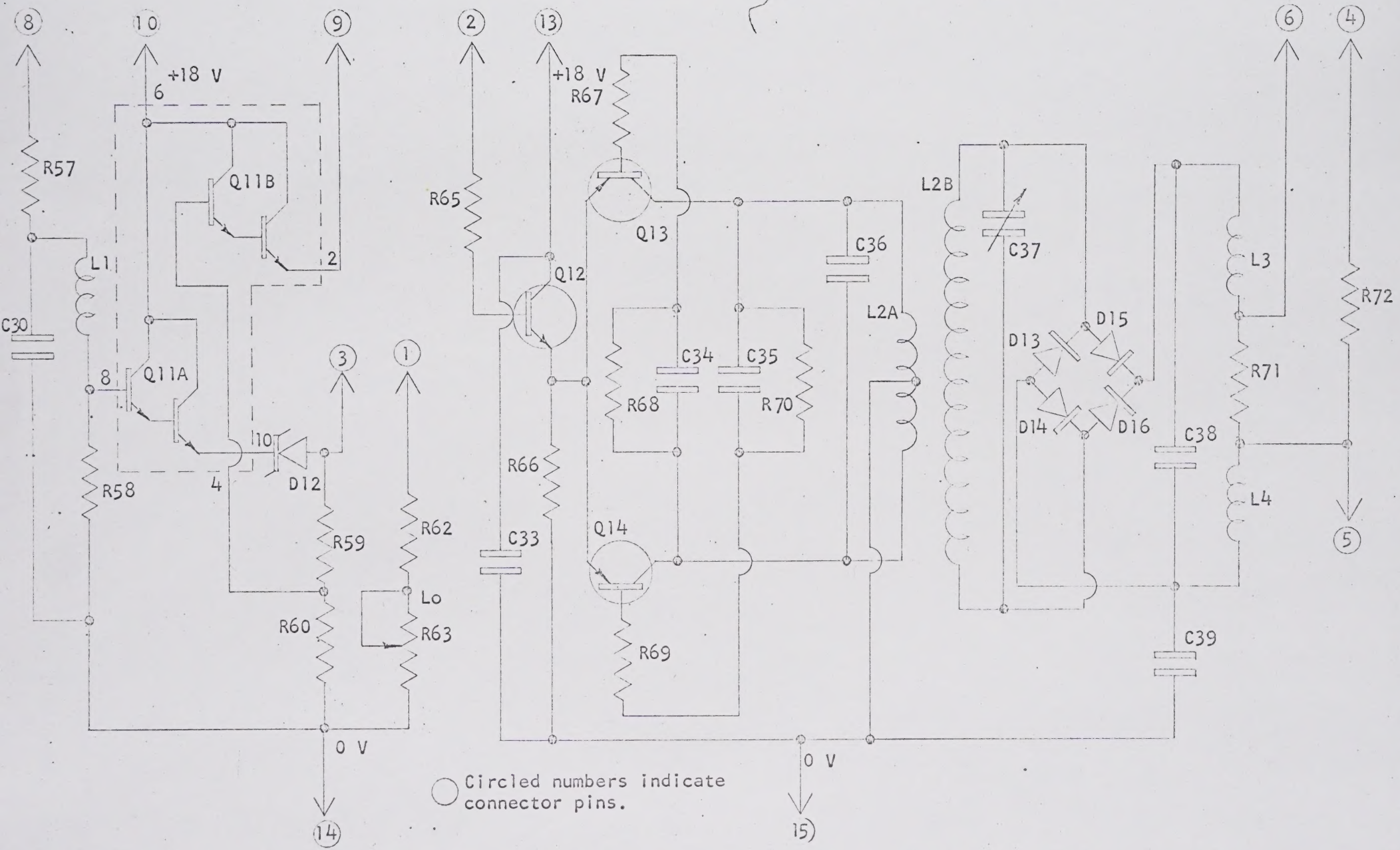
MODEL SD9, S9, SM9 STIMULATORS

POWER SUPPLY CIRCUIT

REF.

APPROVED JDC DATE 4/3/69

CKT. 50351



Circled numbers indicate connector pins.

MODEL S9, SD9, SM9 STIMULATOR

OUTPUT PLUG-IN BOARD #4071

APPROVED JDC DATE 4/4/69

REF. CKT. 50355-1

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